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ABSTRACT

This sixth in a series of eight modules for a course titled Mechanical Inspection describes the duties of the nuclear quality assurance/quality control technician that are associated with protective coatings, and the national standards that govern the selection, application, and inspection of protective coatings for the reactor containment systems. The module follows a typical format that includes the following sections: (1) introduction, (2) module prerequisites, (3) objectives, (4) notes to instructor/student, (5) subject matter, (6) materials needed, (7) procedures, (8) data table, (9) reference materials, (10) test. (The course is one of fifteen technical courses for the second year of a two-year postsecondary curriculum in Nuclear Quality Assurance/Quality Control Technology.) (LRA)

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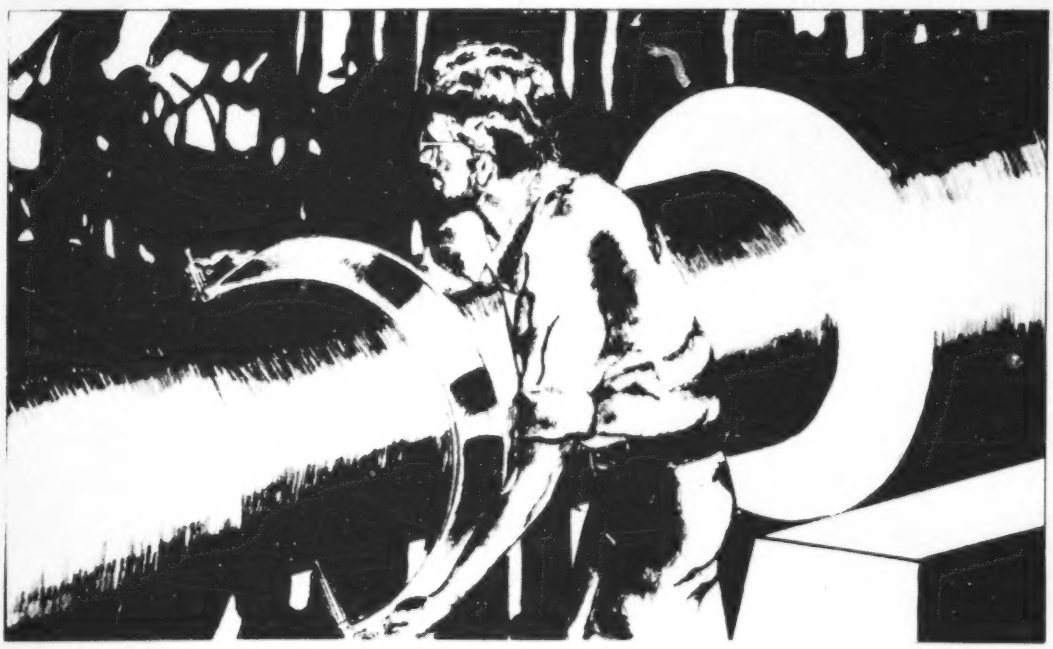
NUCLEAR TECHNOLOGY

COURSE 30 MECHANICAL INSPECTION

MODULE 30-6 Protective Coating Inspection



CE 024 282

GENERAL PHYSICS CORPORATION
Columbia , Maryland

COURSE MODULES

COURSE 30 MECHANICAL INSPECTION

Module 30-1 Pump Inspection
Module 30-2 Pump Functional Testing
Module 30-3 Valve Inspection
Module 30-4 Piping Inspection
Module 30-5 Surface Cleaning Inspection
Module 30-6 Protective Coating Inspection
Module 30-7 Pressure Vessel Inspection
Module 30-8 Rotating Equipment Inspection

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This module was prepared for General Physics Corporation by John Espy, General Physics Corporation.

GENERAL PHYSICS CORPORATION

1979

INTRODUCTION

The Nuclear QA/QC Technician typically has three duties associated with protective coatings. This module presents information to support the performance of these duties which are (1) assuring that qualified paints are used, (2) assuring that proper techniques are employed for application of protective coatings, and (3) inspecting coating thickness and condition.

The term "protective coating" is applied to a wide variety of surface coatings intended to protect the coated surface. Such coatings are typically named for their method of application which includes anodizing, phosphatizing, aluminizing, plating, oxidizing, chromating, cementizing, and painting. Each of these types of coatings can be found to some extent in various parts and components which comprize the nuclear power plant. These coatings are typically applied by the suppliers of the items. However, this module pertains to paints used for protective coatings for nuclear reactor containment facilities.

During the construction phase, protective coatings (paints) are applied within the nuclear reactor containment building for the reasons described by this module. Typical facilities which receive the protective coating are:

- containment structures and shells
- spent fuel carriers
- underwater storage pools and operating equipment
- fuel dismantling areas
- decontamination areas
- maintenance areas
- chemical makeup areas
- off-gas and filtration systems
- solid and liquid waste disposal systems
- water storage tanks

National standards govern the selection, application

and inspection of protective coatings for the reactor containment systems. This module describes the quality assurance provisions of these standards: ANSI N5.9, Protective Coatings (Paints) for the Nuclear Industry; ANSI N101.2, Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities; and ANSI N101.4, Quality Assurance for Protective Coatings Applied to Nuclear Facilities.

MODULE PREREQUISITES

All previous modules in this course must have been completed before proceeding to this module.

OBJECTIVES

Upon completion of this module, the student/trainee can:

1. Define the terms substrate, coating system, run, sag and holiday.
2. State two purposes of protective coatings.
3. State the purpose of qualification of coating materials and describe the relationship of Design Basis Accident to such qualification.
4. State the general purpose of Dynamic Elevated Temperature - Pressure Tests, Irradiation Tests and Contamination - Decontamination Tests.
5. Differentiate between Near-White Blast Cleaned Surface Finish and Commercial Blast Cleaned Surface Finish.
6. Describe the controls placed on coating materials

including supplier's certification, labeling, and sample retention.

7. State the primary purpose of preparation of surfaces of substrates.
8. State three examples of environmental conditions which typically must be controlled during surface preparation of substrates and name three control measures which may be used.
9. Describe the importance of controlling and removing contaminants during surface preparation of substrates.
10. Name five topics which must be addressed by the coating contractor's application procedures.
11. Name four phases of coating work which are inspected by the inspection agency.
12. State the purpose of reports issued by the inspection agency including daily inspection report, nonconformance report, and acceptance report.
13. Describe how to make wet film thickness measurements by the quantity method and by use of fixed gages.
14. Describe the contribution of wet film thickness measurements to the coating system.
15. Describe the principle of operation of dry film thickness measurement gages.
16. Name the type of inspection used and its primary objective when given an element of coating inspection programs.
17. Describe the operation of nondestructive holiday detectors.
18. Calculate dry film thickness when given data on volume of paint used, percent solids, and surface area coated.

SUBJECT MATTER

FUNDAMENTALS

Purpose of Protective Coatings

Protective coatings (paints) serve two primary purposes with respect to reactor containment facilities. These purposes are (1) to protect surfaces from corrosion, and (2) to provide a surface which can be decontaminated.

Engineering may stipulate that surfaces be coated to satisfy either or both purposes. Corrosion protection is provided by prevention of contact of the coated surface with its environment. In addition, primers and paints may be selected which provide cathodic protection or include reactive pigments which set up conditions that impede corrosion. Decontamination capability is provided by the ability to clean the surface of the coating. Such capability becomes increasingly important with the potential accumulation of radioactive material during the 40 year plant life. Also, in the event of an inadvertant leakage of radioactive materials into containment, coated surfaces are much more easily decontaminated.

Basic Terms

A glossary of terms is provided at the end of this module. The student/trainee should refer to the glossary as new terms are encountered. The QA/QC Technician is mostly concerned with the terms substrate, film thickness and those which name defective conditions.

Substrate is the uncoated surface which is to be coated. Regardless of the type of material, e.g., concrete, steel, aluminum, the surface to be coated is termed the substrate. Film thickness is divided into wet-film thickness and dry film thickness. Wet-film thickness is the depth of applied coating immediately after application.

Dry-film thickness is the depth of applied coating when dry.

Wet and dry film thicknesses are expressed in "mils". A mil is equal to 0.001 inch. For example, a 5 mil thickness is equal to 0.005 inch.

Relationship to Design Basis Accident

Reactor design provides for reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. Design processes include the analysis of the ability of safety related systems to prevent or mitigate the consequences of postulated accidents. Such postulated accidents are termed Design Basis Accident (DBA) and establish the environment which protective coatings would see if such an accident occurs.

The environment within containment during a DBA is characterized by steam-air atmospheres at elevated temperature, pressure, and ionizing radiation. Also, water sprays, with or without chemical additives are present. Protective coatings must resist deterioration from such an environment. For this reason, coatings are qualified by a series of tests which simulate the environment of a DBA. Only qualified coatings are used for coating systems.

Qualification Tests

The designer determines the tests necessary for qualifying the coatings to be used in containment. Sample panels of substrates are coated and subjected to the specified tests. Satisfactory performance of the coating as revealed by test results qualifies the coating. That particular brand and type of coating remains qualified provided the supplier does not change formulation such that coating properties substantially change. Typical tests are identified in Table 30-6-1.

Table 30-6-1

QUALIFICATION TESTS		
TESTS	GENERAL PURPOSE	GOVERNING STANDARD
Flame Spread Test	Determine the flame spread rating of the coating. Coating must not be major fire hazard.	ASTM E84, Standard Method of Test for Surface Burning Characteristics of Building Materials.
Thermal Conductivity Test	Develop thermal conductivity data for use in consideration of heat capacity of containment structures in the analysis of DBA.	Appendix A to ANSI N101.2 or ASTM D2214, Tentative Method of Test for Thermal Conductivity Constant with the Cenco-Fitch Apparatus.
Dynamic Elevated Temperature-Pressure Test	Determine the performance of the coating system under DBA environments including water immersion, water spray, vapor, temperature, pressure, and chemicals as predicted by design analysis of DBA.	ANSI N101.2, Protective Coatings for Light Water Nuclear Reactor Containment Facilities.
Irradiation Test	Determine the performance of the coating system when subjected to the integrated radiation dose anticipated during DBA.	ANSI N5.9, Protective Coatings(Paints) for the Nuclear Industry.
Contamination-Decontamination Test	To provide a quantitative evaluation of the ease and the degree of contamination and decontamination of protective coatings.	ANSI N5.9, Protective Coatings (Paints) for the Nuclear Industry.
Chemical-Resistance Tests	To provide a quantitative evaluation of the resistance of protective coatings to chemical environments.	ANSI N5.9, Protective Coatings (Paints) for the Nuclear Industry.
Physical Property Tests	To provide a quantitative evaluation of the physical properties of protective coatings including hardness, abrasion, adhesion, impact resistance, weathering, and flexibility.	ANSI N5.9, Protective Coatings (Paints) for the Nuclear Industry.

The test panels subjected to the dynamic elevated temperature-pressure and irradiation tests are inspected shortly after completion of the tests and again two weeks later. Acceptance criteria are typically no flaking, no delamination or peeling, few intact blisters, and no heavy chalking. Compliance with the acceptance criteria demonstrates that the particular coating will perform satisfactorily if it is subjected to DBA conditions.

Surface Preparation Requirements

For each type of surface to be coated, the project specification stipulates the requirements to be met by the surface of the substrate immediately prior to application of coating. Typical requirements for the substrates of carbon steel, aluminum, galvanized steel, stainless steel, and concrete and masonry surfaces are listed in Table 30-6-2. Descriptions of the grades of surface preparations applicable to carbon steel are contained in Table 30-6-3.

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Table 30-6-2

TYPICAL SURFACE PREPARATION REQUIREMENTS	
SUBSTRATE	TYPICAL REQUIREMENTS
Carbon Steel	For surfaces which under DBA are immersed or continuously exposed to steam or frequently exposed to strong chemicals: - NACE No. 2 or equivalent (see Table 30-6-3) - Welds free from sharp projections and blend smoothly into base metal - All weld spatter removed. - All loose foreign material removed - Crevices, gouges, and joints filled with material compatible with substrate and coating system. - Dry surfaces For surfaces which under DBA are subject to occasional splash, spillage, or exposure to strong decontamination materials: - NACE No. 3 or equivalent - All loose foreign material removed - Crevices, gouges, and joints filled with material compatible with substrate and coating system - Dry surfaces For surfaces supplied with primer applied: - Removal of foreign materials with appropriate cleaning method such as detergents or solvents.
Aluminum	For surfaces which under DBA are immersed: - All welds continuous, free from sharp projections, and blended smoothly into base metal - All weld spatter removed - Uniform surface profile compatible with coating system - Surface clean and dry For surfaces which under DBA are not immersed: - All loose foreign material removed - Crevices, gouges and joints filled with material compatible with substrate and coating system - Surface profile compatible with coating system.
Stainless Steel	- Solvent cleaned and degreased - Crevices, gouges and joints filled with material compatible with substrate and coating system

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Table 30-6-3

GRADES OF SURFACE PREPARATION	
GRADE	DESCRIPTION
NACE No. 1 White Metal Blast (Clean) Surface Finish	Defined as a surface with a gray-white (uniform metallic) color, slightly roughened to form a suitable anchor pattern for coatings. This surface is free of all oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint, and other foreign matter. (Comparable to SSPC-SP 5-63, White Metal Blast Cleaning)
NACE No. 2 Near-White Blast (Clean) Surface Finish	Defined as a surface from which all oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint, or other foreign matter have been removed except for light shadows, streaks, or slight discolorations (of oxide bonded with metal). At least 95% of any given surface area has the appearance of NACE No. 1, and the remainder of that area is limited to slight discolorations. (Comparable to SSPC-SP 10-63T, Near-White Blast Cleaning)
NACE No. 3 Commercial Blast (Clean) Surface Finish	Defined as surface from which all oil, grease, dirt, mill scale, and foreign matter have been completely removed and all rust, mill scale, and old paint have been removed except for slight shadows, streaks, or discolorations caused by rust stain or mill scale oxide binder. At least two-thirds of the surface area shall be free of all visible residues and the remainder shall be limited to light discoloration, slight staining, or light residues mentioned above. If the surface is pitted, slight residues of rust or paint are found in the bottom of pits. (Comparable to SSPC-SP 6-63, Commercial Blast Cleaning).
NACE No. 4 [illegible]	Defined as a surface from which oil, grease, dirt, loose mill scale, loose mill scale, and loose rust are removed, but tightly adhering mill scale, rust, and paint are permitted to remain if they have been exposed to the abrasive blast sufficiently so that numerous flecks of the underlying metal are exposed. Distributed over the entire surface. (Comparable to SSPC-SP 7-63, Brush-Off Blast Cleaning).

ELEMENTS OF QUALITY ASSURANCE FOR PROTECTIVE COATINGS

Five Elements

The nuclear plant owner, or agency thereof, stipulates in a project specification the areas to be coated and the requirements to be met by the coating materials, coating contractor, and inspection agency. The quality assurance program addresses five elements to ensure compliance with the project specification:

- Coating materials
- Surface preparation of substrate
- Application of coating systems
- Coating inspection
- Documentation.

Coating Materials

The quality assurance program ensures use of qualified coating materials. In order to provide such assurance, provisions are made for control of manufacturing of the coating, identification of delivered coatings, labeling, sample retention, performance verification tests, and documentation.

Control of manufacturing is stipulated in procurement documents. The manufacturer of qualified coatings is required to maintain a quality assurance program which documents that the quality of the coating is reasonably identical to that qualified. The program must ensure requalification if there are significant changes in formulation or end-product properties.

Product identity consists of certification by the manufacturer that the product identity of the materials being supplied meet the requirements of the project

specification. Such certification is required for each batch of materials and may be made on the form illustrated by Figure 30-6-1. As described later, product identity is verified at receipt and maintained during use of coating materials.

Labeling of each container is required. Each label identifies the product designation, batch number, and date of manufacture, as a minimum. The product designation and batch number permit association of the manufacturer's certification record with a specific container. The date of manufacture provides the starting point in time for which the shelf life applies.

Sample retention from each batch is required. The coating manufacture retains batch samples for either two years or the shelf life whichever is shorter. This provides the capability to test each batch as may be necessary to resolve disputes on the quality of the materials.

Performance verification tests when required, provide additional assurance of the quality of the materials. The plant owner may require, in the project specification, that specific tests be conducted on the coating materials to be used. These tests may be any of the qualification tests and, when they are required, must be accomplished prior to release of the materials for application. When such tests are required, the owner specifies the exact tests to be performed, what agency is responsible for conducting the tests, the size and number of specimens and their preparation, and provisions for the owner to witness test specimen preparation and conduct of tests.

The minimum documentation with respect to coating materials are the manufacturer's certification and material control records established by the owner and the applicator. The manufacturer's certification attests to the quality of the supplied materials. The owner's and applicator's

SAMPLE FORM 1

COATING MATERIALS - MANUFACTURER'S PRODUCT IDENTITY CERTIFICATION RECORD

GENERAL DATA
(To Be Filled In By Purchaser)

PROJECT DESIGNATION _____ DATE _____

PROJECT LOCATION _____ REPORT NO. _____

OWNER _____ PURCHASE ORDER NO. _____

BUILDING, UNIT, OR EQUIPMENT DESIGNATION _____ CONTRACT NO. _____

SHOP WORK _____

FIELD WORK _____

TECHNICAL DATA
(Submit At Time Of Shipment)

DATE _____

COATING MANUFACTURER _____

PRODUCT NAME & NUMBER _____ GENERIC TYPE _____

BATCH NO. _____ DATE OF MANUFACTURE _____ SHELF LIFE _____

NET WEIGHT, LBS. PER GALLON -- (By ☐ Fed. Test Method Std. No. 141, Method 4184± or By ☐ ASTM D1475)

VISCOSITY RANGE _____ TEMPERATURE _____°F. METHOD _____

SOLIDS VOLUME % ± _____

DRY TIME: _____ HOURS @ _____°F. _____% R.H.

TACK FREE TIME _____ HOURS @ _____°F. _____% R.H.

RECOAT TIME RANGE _____ @ _____°F. _____% R.H.

MINIMUM DRY FILM THICKNESS PER COAT: _____ MILS

COLOR, VISUAL _____

MIXING RATIO _____ PARTS _____ COMPONENT

BY WT. _____ _____ PARTS _____ COMPONENT

BY VOL. _____ _____ PARTS _____ COMPONENT

INDUCTION PERIOD _____ HOURS @ _____°F.

POT LIFE _____ HOURS @ _____°F.

SPECIFIED THINNER _____

FLASH POINT TAG OPEN CUP _____°F. (ASTM D-92)

SIGNATURE _____

TITLE _____

Distribution:

Figure 30-6-1. Manufacturer's Product Identity Certification Form Recommended by ANSI N101.4.

material control records provide evidence that the certified materials were in fact used.

Surface Preparation of Substrates

Surface preparation of substrates is a major factor in the ability to obtain an acceptable protective coating. It has been estimated that 2/3 of the application costs are necessarily associated with surface preparation of substrates. You may have personal experience with adverse painting results caused by inadequate preparation of substrates.

Surface preparation of substrates has the objective of providing adequate adhesion of the coating system to the substrate. The cleanness and profile of the surface are important to accomplishing this objective. In this regard, this element of the quality assurance program addresses conformance with specified requirements, control measures for ambient conditions, removal of contaminants, and documentation.

The coating applicator is responsible for compliance with the requirements for surface preparation of each substrate as specified by the project specification. Typical requirements are those listed previously in Table 30-6-2.

Control measures are typically necessary for ambient conditions. The cleaning process used to prepare substrate and the prepared surface prior to coating may be adversely affected by environmental conditions such as temperature, humidity, and air-born contaminants such as chemical vapors. The project specification stipulates the necessary environmental controls applicable to surface preparation. The coating contractor is responsible for determining that stipulated conditions are met and, if they are not met, arranging with the owner for executio. of control measures.

The control measures, such as heating, cooling, ventilating, and humidity control, must be maintained until the coating is applied. The inspection agency monitors for compliance with these requirements.

The project specification stipulates the control and removal of contaminants which might interfere with application, adhesion, curing, or performance of the coating system. Whether the source of contaminants is the cleaning process or other adjacent construction activities, controls are applied. Compliance with requirements are monitored by the inspection agency. Typically, requirements are necessary to accomplish the following:

- Control and removal of all blasting abrasives, grit, and dust.
- Control of welding fumes and removal of subsequent contaminants.
- Removal of welding scale and spatter.
- Removal of pickling residues.
- Removal of cement spatter, laitance, and mortar.
- Removal of incompatible form-release agents and membrane curing compounds.
- Removal of all other deleterious matter.

The coating contractor is responsible for documenting the surface preparation of substrates. Typically, daily reports are made which identify method of surface preparation, anchor pattern obtained, removal of contaminants, environmental conditions and curing agents used, if any.

Application of Coating Systems

The coating contractor is required to use written procedures for the application of each coating system on each type of substrate. These procedures are typically subject to approval by the owner and the coating supplier. The procedures describe the practices which will be used

by the coating contractor in the following areas:

- Qualification of application personnel
- Receiving, storage, handling, and dispersing coating materials.
- Application equipment
- Application parameters such as environmental conditions, regulation of equipment, ventilation, cleanliness, viscosity, viscosity control, film thickness control, number of coats, curing time, and other pertinent factors.
- Field preparation of coating material such as mixing, thinning, and activating.
- Health, safety, and fire protection requirements.
- Instruments and their use for measuring relative humidity, temperature, viscosity, wet and dry film thickness, and holidays.
- Documentation.

The application equipment and techniques described by the applicator's procedures must be compatible with the project specification and the coating supplier's recommendations for the specific coating material. Qualification of application personnel is based on the documented experience of each person. The documentation must include the basis of personnel qualification, daily reports, and material control records associated with the receipt, storage, handling, and dispensing of coating materials.

Coating Inspection

The owner, or agent thereof, is responsible for inspection of coatings and is termed the inspection agency. The inspection agency is responsible for carrying out inspections of all phases of the coating work. Such inspection is typically performed and reported for the following phases:

- Adequacy of facilities and equipment for storage, mixing, and application.
- Receipt of coating materials
- Substrate before surface preparation
- Substrate following surface preparation
- Application of each coat while wet and the film characteristics after drying.

Inspection personnel must be qualified. The quality assurance program of the inspection agency must describe the training and experience which serves as the basis for qualification. In general, the inspector must be knowledgeable of coating materials and application techniques through training and field experience in quality control of coating applications.

The inspection agency documents results of inspections. Typically, three types of records are completed as follows:

- Daily inspection reports which describe the materials, controls, and environmental conditions being used by the applicator.
- Deviation report which identifies deviations from specified requirements and recommends corrective actions.
- Acceptance inspection report which documents the acceptance of a coating system. This report is based on final inspection and satisfactory completion of the other two records.

Documentation

This element of the quality assurance program applies to the coating material supplier, the coating applicator, the inspection agency and the owner. Typical documentation has been described earlier in this module and is summarized in Table 30-6-4.

Table 30-6-4

QUALITY ASSURANCE DOCUMENTATION FOR COATINGS

Responsible Organization	Documentation
Coating Manufacturer	Product Identity Certification
Coating Purchaser	Receiving and storage records
Coating Applicator	Coating materials handling records Surface preparation record Painter qualification record Coating record Touchup record
Inspection Agency	Inspector qualification record Daily inspection report Nonconformance report Coating system acceptance record
Owner	Coating system acceptance record

COATING INSPECTION TECHNIQUES

Coating inspections determine that requirements of the project specification are met and that nonconformances are corrected as required. Inspection determines that there is strict adherence to procedures by the applicator and that coating results meet specified requirements. This is necessary because paint provides the intended protection only when it is properly applied and when proper film thickness and integrity are obtained.

In the early stages of contracting for coating work, the power plant owner arranges for inspection services. Either the owner's quality control department or a contracted agency may serve as the inspection agency. In either case, an agreement is documented on the extent of inspections to be performed, the acceptance criteria for inspection results, and responsibilities for the correction of noncompliances. The agreement provides for the qualification of inspectors and serves as the quality control program for the inspection agency.

Coating inspections consist of record reviews, visual inspections and inspections with special gages. The elements typically inspected, the type of inspection, and the desired objective are listed in Table 30-6-5

Inspection of Substrates

Visual inspections confirm that surface preparation of substrates meets requirements of the project specification. These inspections typically determine compliance with requirements for the following characteristics:

- moisture in/on concrete or steel substrates
- contaminants on concrete substrates such as form-release agents, membrane curing compounds, or other

Table 30-6-5

ELEMENTS OF COATING INSPECTION PROGRAMS		
Element	Type of Inspection	Inspection Objective
Coating Materials	Record Review	Supplier's product identity certification is adequate
	Visual	Type, quantity, color, condition, and packaging meets requirements.
Storage	Visual	Applicator uses storage conditions as recommended by coating material supplier.
Equipment	Visual	Mixing, application and safety equipment meet specified requirements and are in good operating order.
Safety	Visual	Specified safety precautions are met during the storage, mixing, handling, and application of coating materials.
Substrates	Visual	Specified requirements for surface preparation of substrates are met.
Environment	Visual and gages such as thermometers and hygrometers	Specified environmental controls are met.
Thinning	Visual	Type and quantity of thinner recommended by coating material supplier are used.
Application, Film Thickness, and Repairs	Visual and [illegible]	Specified requirements for [illegible] material, application, thickness, and [illegible]

deleterious matter.

- surface condition of concrete substrates and the remedial work required.
- contaminants on steel substrates such as pickling residues or other deleterious matter.
- anchor pattern on steel substrates
- surface temperature of substrates.

Wet Film Thickness Inspection

Wet film thickness is measured in order to determine that dry film thickness requirements will be met. There is a definite relationship among volume of paint applied per square area, wet film thickness, and dry film thickness.

A gallon container of paint can be pictured as having a film thickness equal to the height of the container over an area equal to that of the base of the container. It follows that if the height is reduced by one-half, the area of the base must increase by a factor of two in order to accommodate a one gallon volume. This relationship applied to coating thickness results in one gallon occupying approximately 1600 square feet at a thickness of one mil. At a thickness of two mils, one gallon occupies approximately 800 square feet. This relationship applies to wet film thickness and is theoretically expressed by the following formula:

$$T_W = \frac{1600G}{A} \qquad \text{Formula 30-6-1}$$

where:

T_W = wet film thickness in mils
G = volume of paint used in gallons
A - area in square feet covered by gallons used

Wet film gages provide a quicker measurement of wet film thickness. These gages are fixed gages similar to

that illustrated in Figure 30-6-2.

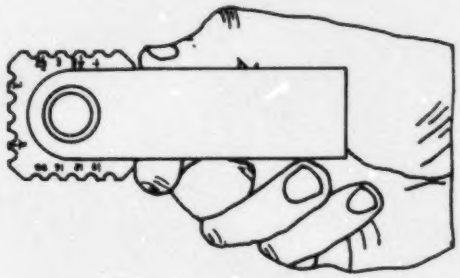


Figure 30-6-2. One type of wet film gage (courtesy of Nordson Corp. Amherst, Ohio)

All wet film gages operate on the same principle. Wet film gages use either comb-like teeth, an eccentric wheel, or a calibrated spherical section. The comb type illustrated in Figure 30-6-2 has two outer legs of equal length and progressively shorter inner legs. The gage is pressed into the wet film in a position perpendicular to the surface and then removed. Wet film thickness is indicated by the shortest leg which has paint on its tip. Wet film readings must be taken immediately after application of the coating.

The relationship of wet film thickness to dry film thickness is directly proportional to the percent solids by volume in the paint. Evaporation of the volatile materials reduces the film thickness upon drying. The relationship is theoretically expressed by the following formula:

$$T_d = T_w \times \frac{V}{100} = \frac{1600G}{A} \times \frac{V}{100} = \frac{16GV}{A} \qquad \text{Formula 30-6-2}$$

where:

T_d = dry film thickness in mils

T_w = wet film thickness in mils
V = percent solids by volume
G = volume of paint used in gallons
A = area in ft^2 covered by paint used

Example

Given

A 10ft x 10ft flat surface is covered with ½ gallon of paint having 50% solids by volume.

Problem

What are the theoretical wet and dry film thicknesses?

Solution

$$T_w = \frac{1600G}{A}$$

$$= \frac{1600 \times .5}{100}$$

$$= 8 \text{ mils}$$

$$T_d = T_w \times \frac{V}{100} \quad \text{or} \quad T_d = \frac{16GV}{A}$$

$$= 8 \times \frac{50}{100} \qquad = \frac{16 \times .5 \times 50}{100}$$

$$= 4 \text{ mils} \qquad = 4 \text{ mils}$$

Wet film thickness gages are used as a guide during coating application. If proper wet film thickness is obtained, there is better assurance of meeting dry film thickness requirements. The project specification may also require calculation of wet film thickness by the quantity method. In either case, the theoretical relationship of wet film thickness to dry film thickness is affected by local circumstances including variation in substrate surface texture (anchor pattern), operator skills and waste, environmental effects, and application techniques. It is normally possible to develop a correction factor for local

conditions. For example, if actual dry film thickness is typically 80% of theoretical dry film thickness, the correction factor of .8 is used in further calculations of dry film thickness.

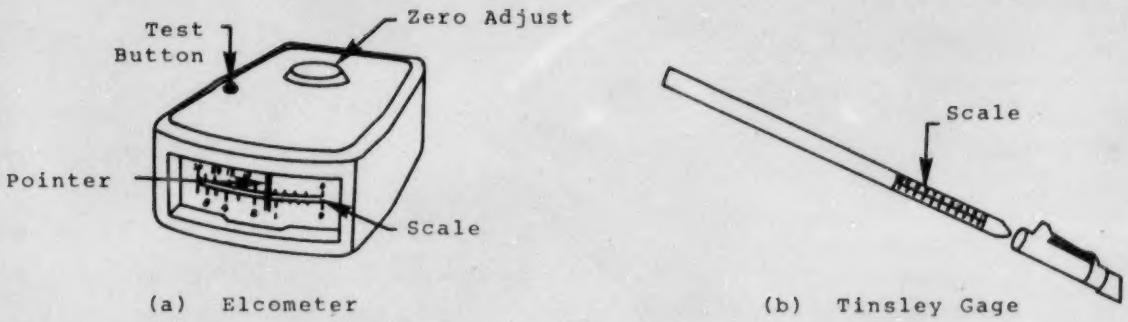
Dry Film Thickness Inspection

Inspection of dry film thickness should be nondestructive in nature. Typically, this is done by Eddy Current testing. Inspection by destructive methods, such as depth pins and scrapings, are used only when allowed by the project specification. Today's state-of-the-art provides nondestructive test instruments for magnetic substrates but not for non-magnetic substrates. For non-magnetic substrates, such as concrete, dry film thickness is typically calculated from wet film thickness measurements although the project specification may permit use of scratch gages or other destructive tests.

There are several kinds of dry film thickness gages on the market for use with magnetic substrates. Simplified sketches of four gages are illustrated in Figure 30-6-3.

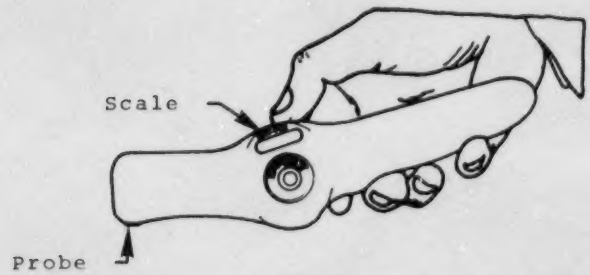
All of the gages illustrated in Figure 30-6-3 work on a magnetic principle. The instrument's response to the magnetism of the substrate is directly affected by the thickness of the coating. The gage is designed to convert this affect to a direct readout of coating thickness. The Elcometer, when placed on the dry film, gives a readout when the test button is depressed. The Tinsley gage uses a small magnetic and a precision spring. Dry film thickness is indicated by how far the magnet pulls the spring. The Microtest and Accuderm measure the magnetic effect between the probe and the substrate and readout in dry film thickness.

The specific gage used has errors. These errors stem from gage inaccuracies, affect of the anchor pattern variations, and magnetic solids in the coating material.

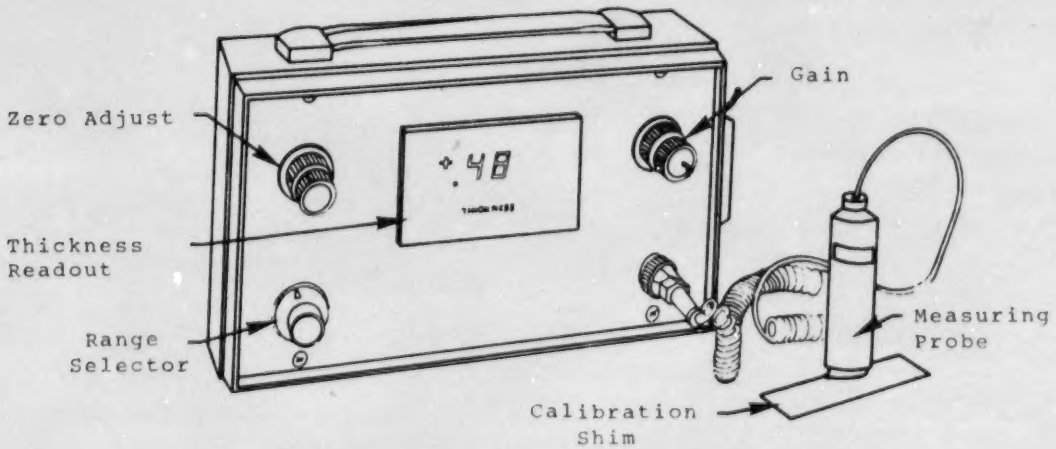


(a) Elcometer

(b) Tinsley Gage



(c) Tooke Microtest



(d) Unit Process Assemblies "Accuderm"

Figure 30-6-3. Simplified Illustrations of Dry Film Thickness Gages.

Calibration shims are used to calibrate the gage. Non-magnetic shims of known thickness are placed on the prepared substrate and read with the gage. Either the gage is adjusted or correction factors are developed to improve accuracy of measurements. In the event a dispute arrises between the owner and applicator on actual dry film thickness, resolution is typically obtained by scraping a small piece of the coating system with a razor down to bare metal and measuring dry film thickness with a depth micrometer.

Holiday Inspection

The project specification may require inspection for holidays by use of special gages. One type of holiday detector uses a high voltage on the order of 8,000 to 15,000 volts and is known as spark testers. As the brush or coil probe passes over the coating, a spark occurs where holidays exist. A more commonly used gage is essentially nondestructive in nature. It employs a low voltage of 75 volts or less and an electrically conductive liquid. The probe is encased in a celulose sponge which is saturated with the liquid. When a holiday is encountered, an electric current flows through the liquid to the substrate metal. Simplified sketches of these nondestructive detectors are illustrated in Figure 30-6-4.

Inspection of Film Appearance

In conjunction with film thichness inspections, visual inspections of film appearance are performed by the inspection agency. These inspections determine if defects exist such as runs, sags, blisters, and skips. Visual inspection may employ workmanship samples which consist of coated panels having least acceptable conditions.

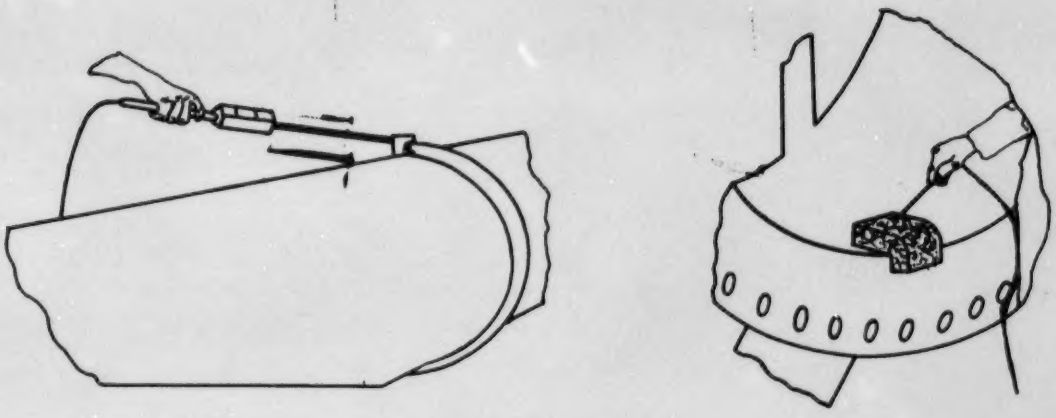


Figure 30-6-4. Simplified Sketches of Holiday Detectors

FINAL ACCEPTANCE CRITERIA

Source of Criteria

The project specification or a supplementary quality assurance document specifies the criteria upon which final acceptance of the coating system is based. The results of visual and gage inspections are compared with the criteria by the inspection agency and the coating system is either accepted or rejected. Final acceptance reports or nonconformance reports document these decisions.

Typical Criteria

Final acceptance criteria typically includes the following:

- film thickness - Dry film thickness is within specified limits.
- runs - Major runs or sags are not acceptable. They must be removed to bare substrate or to a previously accepted coat and recoated.
- skips - Skips and damaged areas are not acceptable. They must be removed to bare substrate or previously accepted coat and recoated.
- pinholes - Pinholes are permitted as specified by the project specification. The specification may stipulate "pinhole free" or describe an acceptable number of pinholes. Typically, no more than two pinholes are permitted in an area defined by a six inch radius as measured from any given pinhole. Any one of the conditions for pinholes listed in Table 30-6-6 may be stipulated by the project specification.

Table 30-6-6

TOTAL NUMBER OF ALLOWABLE PINHOLES

Surface Area Being Coated (square feet)	Cond. "A" Pinhole Free	Cond. "B" Relatively Pinhole Free	Cond. "C" Commercially Continuous
10	0	1	5
10 - 50	0	2	10
50 - 100	0	5	20
100 - 500	0	10	30
500 - 1000	0	15	50
1000 - 5000	0	25	75

GLOSSARY

- Abrasion - wearing away of material in small shreds as a result of friction.
- Abrasive - a substance, such as sand, grit, steel shot, etc. used in blast or abrasive cleaning.
- Acid etch - a process for producing surface profile through dissolution of a surface layer by contact with dilute acid.
- Adhesion - the bond or attraction of a coat of paint to the underlying material, such as a substrate or another coat.
- Anchor Pattern Profile - roughness of a blast-cleaned surface measured by the height from the bottom of a valley to the top of the highest adjacent peak. It depends largely on the original condition of the surface and the abrasive used and should vary for different paint systems.
- Batch - that quantity of material produced in one operation.
- Batch sample - a small retained quantity of material representative of a specific production run.
- Blast cleaning, blasting - the use of abrasives propelled through nozzles or by centrifugal wheels to prepare a surface for coating.
- Blistering - the formation of bubbles in a cured, or nearly cured, coating (paint) film.
- Certification - confirmation by a document under hand or seal as being true or as meeting a standard or as being as represented.
- Chalking - that phenomenon manifested in paint films by the presence of loose, removable powder, evolved from the film itself, at or just beneath the surface. Chalking may be easily detected by rubbing the film with a cloth of contrasting color or with the finger-

tip (ASTM D-659-44).

- Checking - a defect in the paint or varnish coating that manifests itself by slight breaks in the surface of the film.
- Coating applicator - one who applies a protective or decorative coating.
- Coatings (paints) - polymeric materials applied in a fluid phase which cure or dry to continuous films.
- Coating system - a multicomponent polymeric protective film usually consisting of prime, intermediate, and finish coats.
- Coating work - an all-inclusive term to define all operations required to accomplish a complete coating job. The term shall be construed to include materials, equipment, labor, preparation of all surfaces, control of ambient conditions, application of coating systems, inspection, etc.
- Coating-work map - an outline drawing for all areas to be coated, with sufficient detail and identification to clearly define each area. This map shall normally be prepared by the owner or the coating inspection agency.
- Compatible - suitable to be combined with other substances or to adhere properly to other parts of a system; capable of resisting the chemical, physical, and other effects of the intended service condition.
- Concrete-curing agents - materials applied to a concrete surface to maintain proper moisture conditions for curing.
- Contaminant - a foreign substance, inadvertently added to a coating or found on the substrate, that adversely affects the application, adhesion, curing, and/or subsequent performance of the applied coating.

Atmospheric moisture and condensation are considered to be substrate contaminants.

- Contamination - lack of cleanliness of substrate; adulteration of coating product.
- Controlled-access area - in a nuclear facility, a defined area access to which is controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials.
- curing - the changing of the physical properties of a coating by chemical reaction accomplished by the action of heat and/or an activator.
- Decontaminate - to remove radioactive nuclides (the contaminant) from a surface.
- Design-basis accident (DBA) - a hypothesized accident the characteristics and consequences of which are utilized in the design of those systems and components pertinent to the preservation of radioactive material barriers and the restriction of radioactive material release from the barriers. The potential radiation exposures resulting from a design-basis accident are greater than from any similar accident postulated from the same general accident assumptions. For example, the consequences of a complete severance of a recirculation loop line are more severe than those resulting from any other single pipeline failure.
- Deviation - completed work that is not in accordance with the specification requirements.
- Delamination - separation of one coat or layer from another coat or layer.
- Documentation - The assembling or dissemination of written information or records in substantiation of work done or facts quoted.
- Dry-film thickness (DFT) - depth of applied coating when dry, expressed in mils.

- Flaking (Scaling) - the detachment of small pieces of the coating film. This is usually preceded by cracking, checking, or blistering.
- Form-release agent - the oil or plastic coating used on concrete forms to reduce damage to the concrete and to the forms when they are stripped from the hardened concrete.
- Holiday - a pinhole, skip, discontinuity, or void in coating film.
- Holiday detector - a device for the detection of pinholes or holidays.
- Inspection - examination to determine conformance to specifications.
- Inspection agency - a person or persons empowered to act for the owner to verify conformance of the coating work with documented specifications, instructions, and procedures. The inspection agency may be part of the owner's or his representative's organization, may be a representative of the coating manufacturer or the coating applicator or may be an independent organization, provided the inspection personnel do not report directly to the immediate supervisor responsible for the coating work.
- Interface - the boundary between coats, phases, or systems.
- Laitance - a fine, whitish accumulation on concrete surfaces. It consists mainly of cement particles that were carried by water rising to the surface of freshly placed concrete. The resulting concrete surface is unsuitable for proper adhesion or bond of subsequent fillers or protective coatings.
- Magnetic gauge - an instrument that will nondestructively measure the thickness of a nonmagnetic coating over a ferrous substrate.

- Masonry - a built-up construction consisting of building units made of clay, shale, concrete, stone, etc., set in mortar.
- Mil - one one-thousandth of an inch (0.0254 millimeters)
- Pickling - a surface treatment for steel to remove rust and mill scale by immersion in an acid solution which may contain an inhibitor.
- Pot life - the time interval at a specified temperature, after the components of chemically cured coatings have been combined and mixed, during which the mixed material displays normal application and film-forming properties.
- Primer - the first complete coat of a coating system applied to a surface. The type of primer varies with the surface, its condition, the intended purpose, and the coating system to be used.
- Profile - a surface roughness resulting from abrasive blasting, chemical etching, or other cause. It is a measure of the anchor pattern.
- Profile depth - the distance measured perpendicular to the surface between adjacent high and low points of a profile.
- Project specification - a written document designed to ensure execution of the coating work for a project in accordance with the owner's requirements. It is usually comprised of general, legal, and technical specifications governing the work, together with related pricing requirements.
- Protective coating - an adherent polymeric film applied to a substrate for protection from environmental attack and for esthetic effect.
- Runs - the flow of an excessively applied coating which results in an elongated pattern of irregular coating films over a small vertical or sloped surface

area such as a point or an angle.

- Sags - the flow of an excessively applied coating which results in a broad pattern of irregular coating films over a large vertical or sloped surface area.
- Scratch gage - an instrument that makes a cross-sectional scratch through a coating and optically measures its thickness. It may be used on any nonbrittle coating over any substrate.
- Shelf life - the period of time, as stated by the coating manufacturer, during which a coating does not become unusable.
- Spatter - deposit on or adjacent to weld seams produced by weld metal during electric hand welding operation. It is inacessible for painting, and the sharp forms do not lend themselves to being coated; therefore it must be removed prior to painting.
- Substrate - the uncoated base surface to which a coating is to be applied.
- Surface defects - the existence in a coating of any of the following conditions which impair its performance for the intended service: (a) fine-line cracking, (b) checking, (c) alligatoring, (d) mud-cracking, (e) embrittlement, etc.
- Surfacer - a material used to fill and smooth a surface.
- Wet-film thickness (WFT) - the depth, expressed in mils, of an applied coating measured immediately after application.
- Work - all or any part of such labor (including the services of all trades), methods, materials, equipment, and transportation or other facilities as may be necessary to complete the contract.

EXERCISES

The following exercises serve to review the material presented in this module. An answer key is also provided following each section.

A. The following exercises concern the Fundamentals of Protective Coatings.

1. Name two purposes of protective coatings.
   a.
   b.

2. Define these terms:
   a. Substrate

   b. Wet film thickness

   c. Dry film thickness

   d. Mil

3. What is the purpose of qualifying coating materials?

4. Describe the relationship of coating material qualification tests with Design Basis Accident.

5. Describe the condition of a Near-White Blast Cleaned Surface Finish.

6. Describe the condition of a Commercial Blast Cleaned Surface Finish.

Check your answers for these exercises on the Fundamentals against the following answer key:

1. a. To protect surfaces from corrosion
   b. To provide a surface which can be decontaminated

2. a. Substrate is the uncoated base surface to which a coating is to be applied-
   b. Wet film thickness is the depth in mils of an applied coating measured immediately after application.
   c. Dry film thickness is the depth in mils of applied coating when dry.
   d. Mil is one-one thousandth of an inch (0.001").

3. To determine that the coating material will resist deterioration when subjected to the environment of a Design Basis Accident.

4. The qualification tests simulate the environment of a DBA including steam-air atmospheres, elevated temperatures, ionizing radiation, and immersion or spray with and without chemicals.

5. Near-white blast cleaned surface finish has at least 95% of any given area free of all foreign material with the remaining area having only slight discoloration.

6. Commercial blast cleaned surface finish has at least 2/3 of the surface area free from all foreign material with the remaining area having only light discoloration, slight staining, or light residues.

B. The following exercises concern the Elements of Quality Assurance for Protective Coatings by circling the letter of the best choice for the following questions and statements. An answer key is provided following this set of exercises:

1. The primary objective of the coating material supplier's quality assurance program is to:
   a. qualify applicators of coating systems.
   b. control formulation and processing.
   c. inspect wet film thickness.
   d. document application techniques.

2. Coating material product identification is primarily provided by:
   a. receipt inspection
   b. supplier's certification
   c. deviation reports
   d. inspection reports

3. The minimum information provided by labeling of protective coating containers is:
   a. product designations, and shelf life.
   b. product designation, percent solids and certification number.
   c. product designation, batch number, and date of manufacture.
   d. product designation, percent solids and batch number.

4. Sample retention by the coating material supplier is to provide samples for:
   a. shelf life testing
   b. prequalification testing

c. coating test panels
d. additional testing to resolve disputes

5. The purpose of surface preparation of substrates is to provide:
   a. adequate adhesion of the coating system.
   b. cleanliness conditions suitable for inspection
   c. bright polished and smooth surfaces
   d. DBA environmental conditions.

6. Environmental conditions which may adversely affect the substrate are (circle all correct responses)
   a. temperature
   b. humidity
   c. chemical vapors
   d. vibration

7. Contaminants are removed from substrate surfaces because contaminants may:
   a. interfere with coating application.
   b. cause lack of adhesion.
   c. interfere with curing.
   d. all of the above.

8. The term "coating system" means:
   a. the method of application of coating.
   b. the substrate to be coated.
   c. the protective film usually comprized of primer, intermediate and finish coats.
   d. the composite procedures for surface preparation, coating application and inspection.

9. The purpose of daily inspection reports is to:
   a. record dry film thickness.
   b. report deviations.
   c. describe practices employed by the applicator.
   d. accept coating systems.

10. The deviation report serves to:
   a. record wet film thickness.
   b. accept coating systems.
   c. obtain correction of conditions which fail to meet specified requirements.
   d. describe the inspection program for coating applications.

11. The acceptance inspection report serves to:
   a. accept coating systems.
   b. report deviations.
   c. describe daily conditions.
   d. document removal of contaminants.

Check your answers on the exercises covering the Elements of Quality Assurance for Protective Coatings against the following answer key.

1. b
2. b
3. c
4. d
5. a
6. a, b, c
7. d
8. c
9. c
10. c
11. a

C. The following exercises cover the information on Coating Inspection Techniques. An answer key is provided following this set of exercises.

1. Define:
   a. run

   b. sag

   c. holiday

2. Why are set film measurements made? (State two reasons)

3. What type of inspection is used for thinning of coating materials and what is its primary objective?

4. Describe how to make wet film thickness measurements using the quantity method.

5. Describe the principle of operation of dry film thickness gages.

6. Why are dry film thickness gages not used on common concrete substrates?

7. Calculate dry film thickness given:
   percent solids - 40%
   volume of paint - 3 gallons
   area covered - 600 ft^2

8. Describe the use of calibration shims.

9. Describe the operation of nondestructive holiday detectors.

10. Describe the measurement of wet film thickness with a comb type wet film gage.

Check your answers to the exercises on Coating Inspection Techniques against the following answer key:

1. a. run is the flow of excessively applied coating which results in an elongated pattern of irregular coating films over a small vertical or sloped area.
   b. sag is the flow of excessively applied coating which results in a broad pattern of irregular coating films over a large vertical or sloped area.
   c. holiday is a skip, pinhole, discontinuity, or void in coating film.

2. a. to serve as a guide during application to determine that correct film thickness is being applied.
   b. to permit calculation of dry film thickness.

3. Visual inspection having the objective of ensuring compliance with requirements for thinning material type and quantity.

4. The volume of paint used in gallons and the area covered in square feet by that volume are measured. Using the formula $T_W = \frac{1600G}{A}$, wet film thickness is calculated.

5. Dry film thickness gages are sensitive to magnetic materials. The degree of interference by the non-magnetic dry film is converted by the gage to dry film thickness.

6. Common concrete substrates are nonmagnetic and therefore do not produce a reading on the gage.

7. 3.2 mils

$$(T_d = \frac{16GV}{A} = \frac{16x3x40}{600} = 3.2)$$

8. Calibration shims are nonmagnetic and of known thickness. Reading the shims placed on the substrate indicate accuracy of gage.

9. A low voltage is applied between the detector probe and the substrate. Electrically conductive fluid is pushed by the probe along the coating film. Holidays in the film permit current flow through the fluid which indicates their presence.

10. Immediately after application of coating material, the wet film gage is pressed at right angles into the film and withdrawn. Evidence of paint on the shortest leg indicates wet film thickness.

D. Film Thickness Calculations and Inspection

1. Using the Procedures given in this module, calculate wet or dry film thickness as outlined in the procedure.

2. Inspect dry film thickness of a coating system as outlined in the Procedures.

MATERIALS

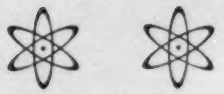
The following materials are required to support this module:

1. Wet film thickness gage (any type)
2. Dry film thickness gage (any kind)
3. Calibration shims compatible with the dry film thickness gage
4. Copy of coating applicator's procedures (optional)
5. Copy of coating project specification (optional)

PROCEDURES

1. As requested in Exercise 1 of Part D of the Exercises section, calculate wet or dry film thickness as indicated for the following given conditions:
   a. Eight gallons of primer having 60% solids by volume are used to coat 4800 square feet. Known application efficiency is 80%.
      dry film thickness =
   b. A finish coat is applied with paint having 40% solids by volume in a manner which gives a wet film thickness of 5 mils.
      theoretical dry film thickness =

2. As requested in Exercise 2 of Part D of the Exercises section, inspect dry film thickness of a coating system identified by the instructor using available gages. Complete data table 30-6-7 to document the inspection.



DATA TABLE

Table 30-6-7

DRY FILM THICKNESS DATA TABLE

Name of gage used: _____

Calibration data:

Shim	Gage Reading

System inspected: _____

Dry film thickness: _____

3. Visually inspect a coating system identified by the instructor. Complete data table 30-6-8.

Table 30-6-8

Visual Inspection Data Table

System inspected _____

Defects:	Present	Not Present	Location
Sags			
Runs			
Blisters			
Holidays			

REFERENCE MATERIALS

ANSI, N101.4, Quality Assurance for Protective Coatings Applied to Nuclear Facilities, American Institute of Chemical Engineers, 1972

ANSI, N101.2, Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities, American Institute of Chemical Engineers, 1972

ANSI N5.9, Protective Coatings (Paints) for the Nuclear Industry, American Institute of Chemical Engineers, 1967

NACE, Coatings and Linings Handbook, National Association of Corrosion Engineers, 1978

NACE, Surface Preparation Handbook, National Association of Corrosion Engineers, 1977

NACE, Industrial Maintenance Painting, National Association of Corrosion Engineers, 1978

Clive H. Hare, A Layman's Guide to Surface Coatings and Their Application, Cadillac Paint and Varnish Company, Inc., undated

NACE, Basic Corrosion Course, National Association of Corrosion Engineers, 1977

Thomas A. Cross, Corrosion Control Coatings, Plant Engineering, Technical Publishing Company, December, 1978

USNRC, Regulatory Guide - Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants, U.S. Nuclear Regulatory Commission, 1973

A. Answer the following questions as either true or false.

____ 1. Protective coatings (paints) serve three primary purposes with respect to reactor containment facilities. These purposes are:
   a. to protect surfaces from corrosion,
   b. to provide a vapor barrier for the reactor building walls, and
   c. to provide an additional shielding layer to provide biological protection from the Nitrogen - 16 gamma radiation present in the containment building.

____ 2. The surface to be coated is the substrate and the films applied comprise the coating system.

____ 3. Defects in coating systems typically consist of runs, sags, and holidays. Failure to meet dry film thickness requirements is also a deviation.

____ 4. The cleaning process to prepare the substrate prior to coating may be adversely affected by such things as temperature, humidity, radioactive effluents, smoke, and excessive sunlight.

____ 5. Protective coatings protect the substrate from corrosion and offer a surface which can be decontaminated.

____ 6. Coating materials are qualified under conditions which simulate the environment of the Cold Water Accident. Once qualified, the supplier's quality assurance program must control formulation and

processing such that material performance is unaffected or requalification occurs.

____ 7. The contamination-decontamination tests provide quantitative evaluation of the ease and degree of contamination and decontamination of protective coatings.

____ 8. The dynamic elevated temperature-pressure test determines performance of the coating system under the moisture-temperature-pressure-chemical environment anticipated during caustic corrosion of the reactor coolant system within the containment building.

____ 9. The irradiation test determines the performance of the coating system when subjected to a radiation dose anticipated during a Design Basis Accident.

____ 10. Near-White and Commercial blast cleaned surface finishes are the two most common preparations of steel substrates. The major differences in these finishes is the percentage of area to be clean to bare metal and the extent of foreign matter on the remaining area.

____ 11. Product identity of coating materials is provided by the material supplier's certification of each batch.

____ 12. Each container of coating materials is labeled to identify product designation, specific gravity, and latent heat of vaporization.

____ 13. Samples of each batch of coating materials are retained by the manufacturer for two years or the shelf-life whichever is shorter. These samples permit additional testing if necessary to resolve disputes on the quality of the materials.

____ 14. The owner may require the applicator to conduct performance verification tests of the coating materials to be used. These tests are typically the Eddy Current Test, the Charpy V-Notch Test and the Bend Test.

____ 15. Surface preparation of substrates is extremely important in that the crystalline structure must shift from a face-centered-cubic mode to a body-centered-cubic mode.

____ 16. Control and removal of contaminants is necessary during preparation of substrate surfaces. This includes control or removal of blasting abrasives, grit, and dust; welding fumes and subsequent contaminants; welding scale and spatter, pickling residues; cement spatter, laitance, and mortar; incompatible form release agents and curing compounds; and any other deleterious matter.

____ 17. The environmental conditions of temperature, humidity and vapors are virtually unimportant when the application of coatings is considered. This is because of the tremendous adhesive nature of these coatings.

____ 18. The applicator uses written procedures for controlling coating work. These procedures describe the practices used for qualification of applicators; receiving, storage, handling, and dispensing of coating materials; application equipment; application parameters such as environmental conditions, regulation of equipment, ventilation, cleanliness, viscosity, viscosity control, film thickness control, number of coats, and curing time; preparation of coating materials such as mixing, thinning, and activating; health, safety, and fire protection requirements; instruments and their use for measuring relative humidity, temperature, viscosity, wet and dry film thicknesses, and holidays; and the documentation to be provided.

____ 19. The inspection agency issues daily inspection reports, acceptance inspection reports, and as necessary, deviation reports.

____ 20. Dry film thickness measurements serve as a guide to the applicator and permit calculation of wet film thickness.

____ 21. Dry film thickness gages work on a magnetic principle and are used for film thickness measurements of magnetic substrates. Nonmagnetic shims of known thickness are used to calibrate these gages.

____ 22. Inspections are comprized of record reviews, visual inspection, and special gage inspections. Inspection elements include coating materials, storage, equipment, safety, substrates, environment,

thinning, application, film thickness, and film appearance. Can you state the primary objective of inspection of each of these elements?

____ 23. Holiday detectors may be destructive (spark types) or nondestructive (low voltage-electrolyte types). Those normally permitted are nondestructive which detect holidays by the passing of a current flow through the conductive fluid at locations of holidays.

____ 24. A controlled-access-area in a nuclear facility is an area to which access is controlled for the expressed purpose of protecting individuals from inhaling toxic airborne fumes from protective coatings.

____ 25. A coating-work map is supplied to each person applying protective coatings so that they don't get lost in the plant.